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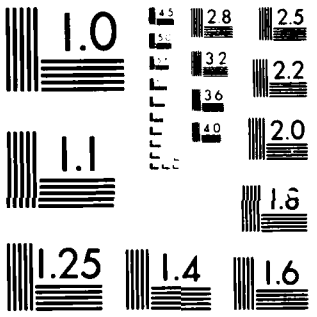

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MOTION COMPARISON BETWEEN A 64-FOOT SWATH AND A 65-FOOT MONOHULL

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A comparative evaluation of the seakeeping capabilities of a 64-foot SWATH craft and a 65-foot monohull was conducted by the Naval Biodynamics Laboratory, New Orleans, Louisiana, during a two-day period in November 1984. The trial was conducted at the mouth of the Columbia River, Astoria, Oregon. The seakeeping trials measured the hull motions of the two vessels during comparable sea conditions. These conditions approximated the maximum environmental conditions under which the vessels would normally be expected to conduct hydrographic surveying missions. Measurements of pitch, roll, and vertical and transverse acceleration of the hydrographic crew's work station were obtained for each vessel. The seakeeping trials indicated that the SWATH hull provided a significantly more stable platform from which to conduct hydrographic surveying missions when the human operator is considered. Compared to the monohull, the SWATH hull can be expected to reduce the overall incidence of motion sickness and to improve human performance.

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PREFACE

The work described in this report was performed by the Motion Sciences Department, Naval Biodynamics Laboratory (NBDL), New Orleans, LA, for the United States Army, Marine Design Center, Philadelphia, PA and the Naval Sea Systems Command, Washington, DC. The work was requested by the Commanding Officer, Naval Medical Research and Development Command, Bethesda, MD to assist the Army Corps of Engineers in evaluating SWATH craft for hydrographic surveying operations. Support was provided by in-house sea-trial contingency funds from project number MF58524. No other direct or indirect support was provided.

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INTRODUCTION

The United States Army Marine Design Center, Philadelphia, PA has been evaluating existing and advanced surface craft concepts to support the replacement process for the Corps of Engineers' conventional monohull hydrographic surveying vessels. The Small Water Plane Area Twin Hull (SWATH) design is being evaluated currently for the hydrographic mission. The Naval Biodynamics Laboratory (NBDL) was tasked to provide an evaluation of the effects of SWATH designs on human performance based on measured vessel motion during the worst possible conditions under which surveying would normally be conducted. The data acquired were to be used as part of the data base for current and future design decisions. This evaluation consisted of comparing the vessel motions of the current 65-foot monohull being employed for hydrographic data acquisition and a 64-foot commercially available SWATH. The data consisted of recorded hull motions at the surveyor's crew station. These data were used to determine the most likely effect these motions would have on mission performance.

Trials were conducted on the M/V Hickson, a 65-foot conventional monohull currently in use by the Army Corps of Engineers for hydrographic surveying in the Columbia River Region of Northern Oregon and on the M/V Suave Lino, a commercially available 64-foot SWATH owned and operated by Seaco, Inc. of San Diego, California. Calm water evaluation of the seakeeping performance of the Suave Lino has been reported in detail previously (1). Since that trial, the Suave Lino has been modified to include an additional 7 x 24-foot cabin space behind the pilot house, and additional deck material handling equipment. The Suave Lino is illustrated in Figure 1a and the underwater profile is given in Figure 1b. The Suave Lino is equipped with roll and pitch fin stabilizing equipment which was in operation during the trials. The Hickson, which is illustrated in Figure 2, does not support any stabilization equipment.

SEAKEEPING

Trials were conducted over a two-day period in November 1984. The trial plan did not include calm water evaluation because these data have already been reported for the Suave Lino and because human performance decrements are unlikely to be a significant factor between the two vessels in a minimal sea. The initial seakeeping trials were planned for the area abreast of Clatsop Spit, at the mouth of the Columbia River, Oregon. Gale warnings during the period forced the trial to be moved into safer waters southwest of Sand Island. A bouy-to-bouy course was laid out and is illustrated in Figure 3. Due to the limited seaway available in the operating area, not all course headings could be conducted, and each leg was shorter than desired. Therefore, data for several short legs were averaged to produce the final data. A portion of the trial with the SWATH was moved further up the river to avoid worsening sea conditions that would have been well outside the operating range of a hydrographic mission (see Figure 3). Both vessels traversed the course at 14 knots indicated, the speed at which the conventionally-hulled vessel normally performs the mission. It should be noted that for SWATH vessels, increasing speed improves seakeeping, and the Suave Lino would have shown improved performance had its cruise speed of 18 - 20 knots been used for the trial. Data during the frequent turns were not used in the analysis. Winds were northeast at an average speed of 22 knots during all seakeeping trials. Figure

4a indicates the minimum sea encountered in the trial, and figure 4b the maximum sea encountered. Seas were estimated at 6 - 8 feet, with occasional waves 12 - 15 feet (estimated sea state 4). The sea was predominantly swell with a period of 9.5 seconds. During the final runs with the Suave Lino, the waves became short crested. Under these conditions, the Hickson was unable to continue the trial due to severe pitching.

The craft were instrumented with a ship motion recorder (SMR) provided by the David Taylor Naval Ship Research and Development Center. The SMR was placed on the centerline and at the same frame as the hydrograhic crew's station. This position was forward of the center of gravity for both vessels. For trial purposes, the crew station location for the Suave Lino was placed in the pilot house on the starboard side of the wheel. The crew station for the Hickson is situated on the port side and aft of the wheel. Peak and root mean square (RMS) values were obtained at two-minute intervals for roll and pitch in degrees, and transverse acceleration and vertical acceleration in g's. A minimum of ten measurements were taken for each heading.

The acceleration and motion data (single amplitude) are presented in Figures 5 and 6, and the heading nomenclature is provided in Figure 7. Maximum vertical acceleration occurred in a head sea for both the SWATH and the monohull. The SWATH vertical acceleration was, however, less than half that of the monohull. Similar results were obtained for transverse acceleration. The SWATH exhibited less than half the acceleration at all headings than did the monohull. The SWATH demonstrated less pitch and roll at all headings as well. The smallest difference between the two vessels was found in the amount of pitch. The largest difference was found for roll. (It should be noted that the SWATH was stabilized for pitch and roll, and the monohull was not. Comparative data should be taken on roll-stabilized monohulls for unbiased comparisons.) Occasional waves in excess of 12 feet were encountered during the trial. On one occasion in a head sea, a particularly large wave was taken by the SWATH, producing a slam. These data are indicated by the dotted lines in Figures 5 and 6. No comparable data were obtained for the monohull.

DISCUSSION

Ship motion may be expected to affect human performance in at least two ways. First, the motions of the vessel may interfere with the biomechanical movements necessary to perform a task (2). Such activities as writing and precise marking on maps that are necessary for the hydrographic survey mission may reasonably be expected to be disrupted by ship motion. Second, there is evidence that suggests that ship motion may also affect cognitive performance (3,4). The range of motions observed for the monohull fall within the range reported to affect cognitive performance by these authors.

Vertical accelerations in excess of 0.20 g, for example, tend to produce discomfort (5). At the operating speed of 14 knots and in a maximum seaway for hydrographic surveying, the SWATH RMS vertical acceleration did not exceed this value for any heading, whereas the monohull exceeded this value for head and beam seas. A similar conclusion can be drawn from the roll data. The incidence of motion sickness can also be expected to be considerably higher on the monohull. During the monohull trial, one individual was clearly ill, whereas there was no indication of motion sickness aboard the SWATH. Though the hydrographic team, typically consisting of one or two persons, was not

present during the trials of either craft, interviews with these individuals at dockside indicated that they exhibited significantly less motion sickness while working aboard the SWATH.

In addition to the general effects of roll, pitch, and heave motion, performance degradation due to slamming must also be considered. This type of motion has received little attention in terms of performance effects from shipboard studies, and only limited investigation has been conducted in the laboratory (6). This factor may be of greater significance for hulls such as the SWATH. During this trial, only one significant slam was encountered, and this occurred in sea conditions in which surveying would normally be curtailed with a similar size displacement hull. Though slamming should be considerd as a factor in overall vessel operation, it is not likely to play a significant role during routine hydrographic operations (assuming curtailment of these operations under heavy seas).

The data collected during this trial indicate that the SWATH vessel would provide a more stable platform from which to conduct hydrographic surveys than the monohull design. Consequently, performance of the survey team can be expected to be superior aboard the SWATH vessel, as compared to performance aboard the monohull vessel, under the sea conditions in which these operations would be conducted, especially under the most extreme of these conditions.

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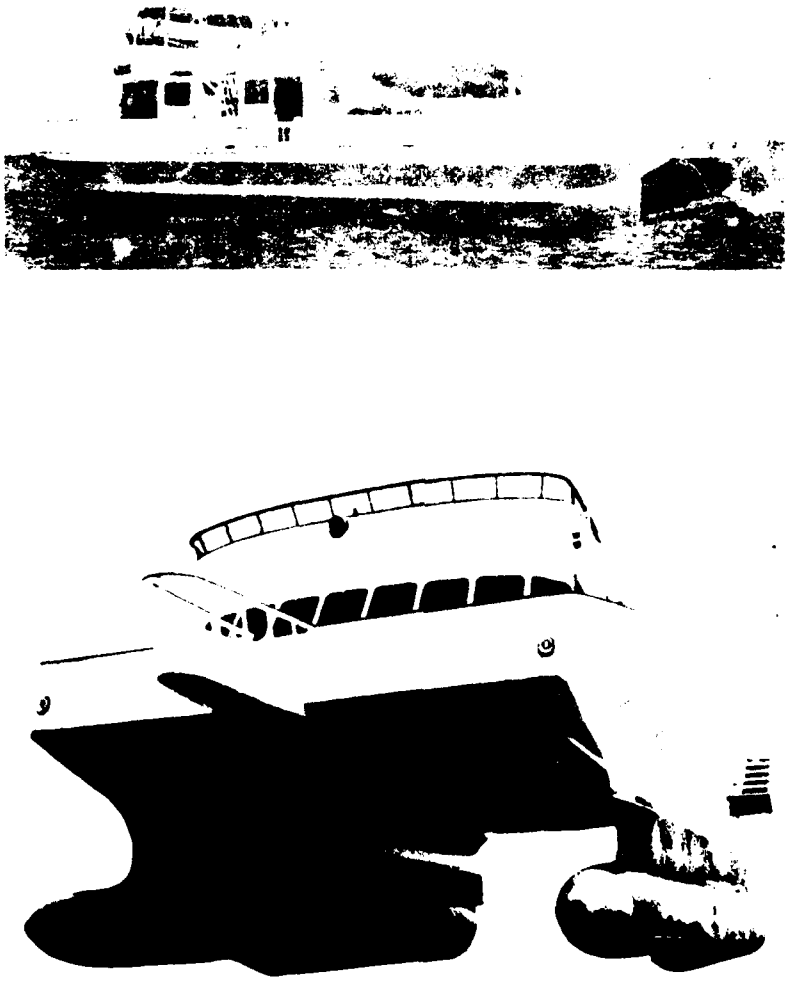

Figure 1. Two views of the 64-foot SWATH M/V Suave Lino.

Figure 2. 65-foot Hickson transiting channel to trial area.

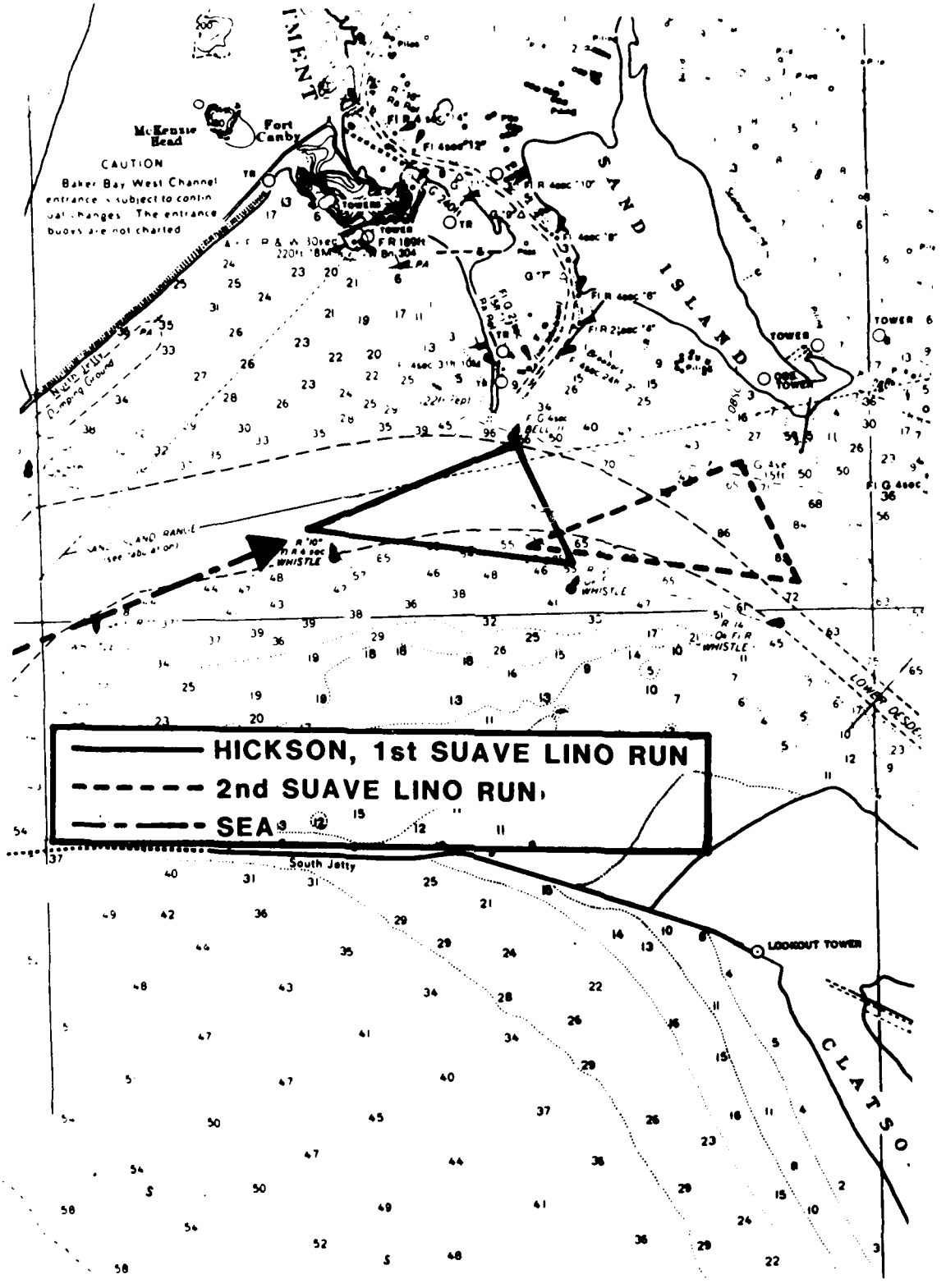

Figure 3. Location of trials for the two craft.

A

B

Figure 4. Views of minimum (A) and maximum (B) sea conditions for the trial.

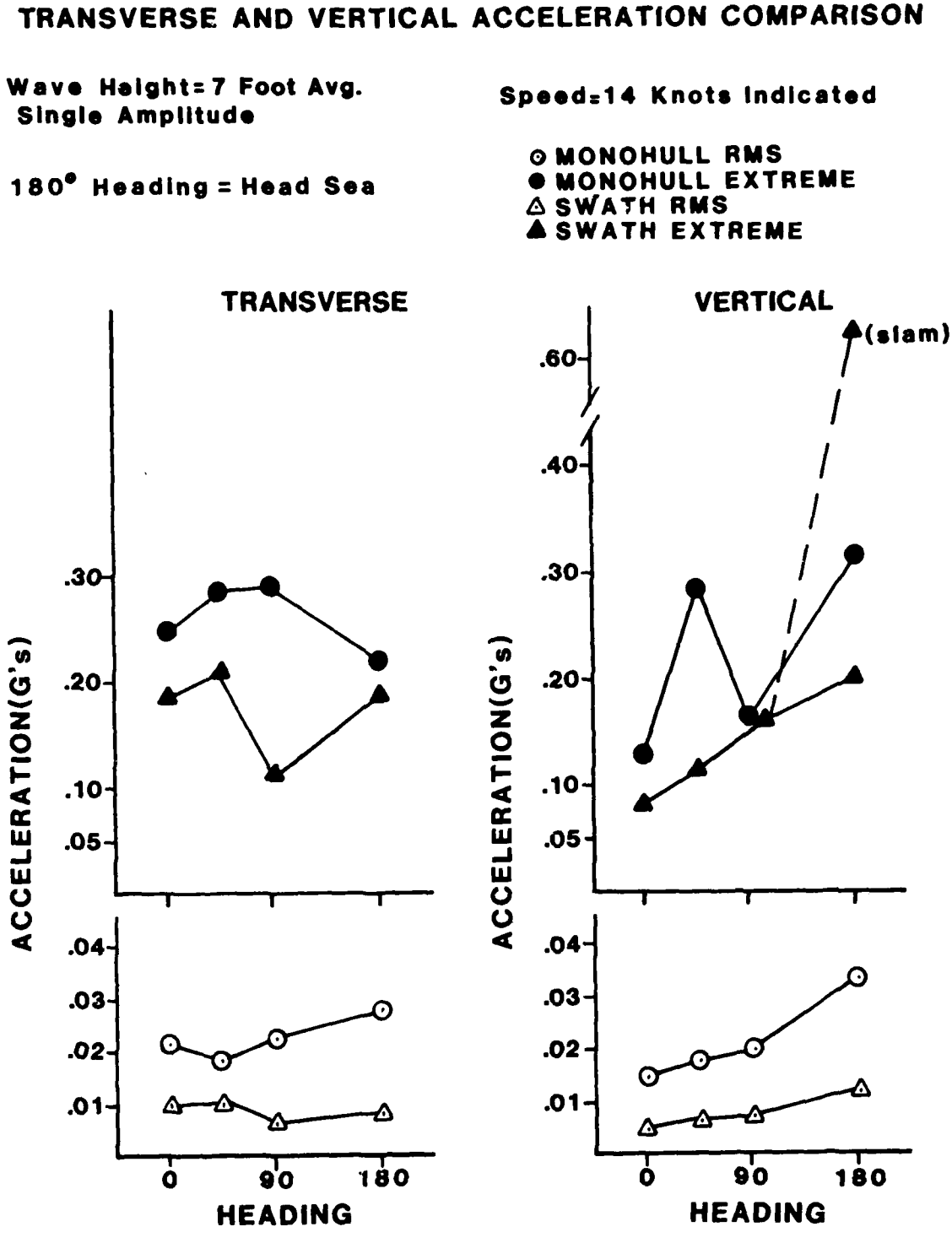

Figure 5. Transverse and vertical acceleration comparison data.

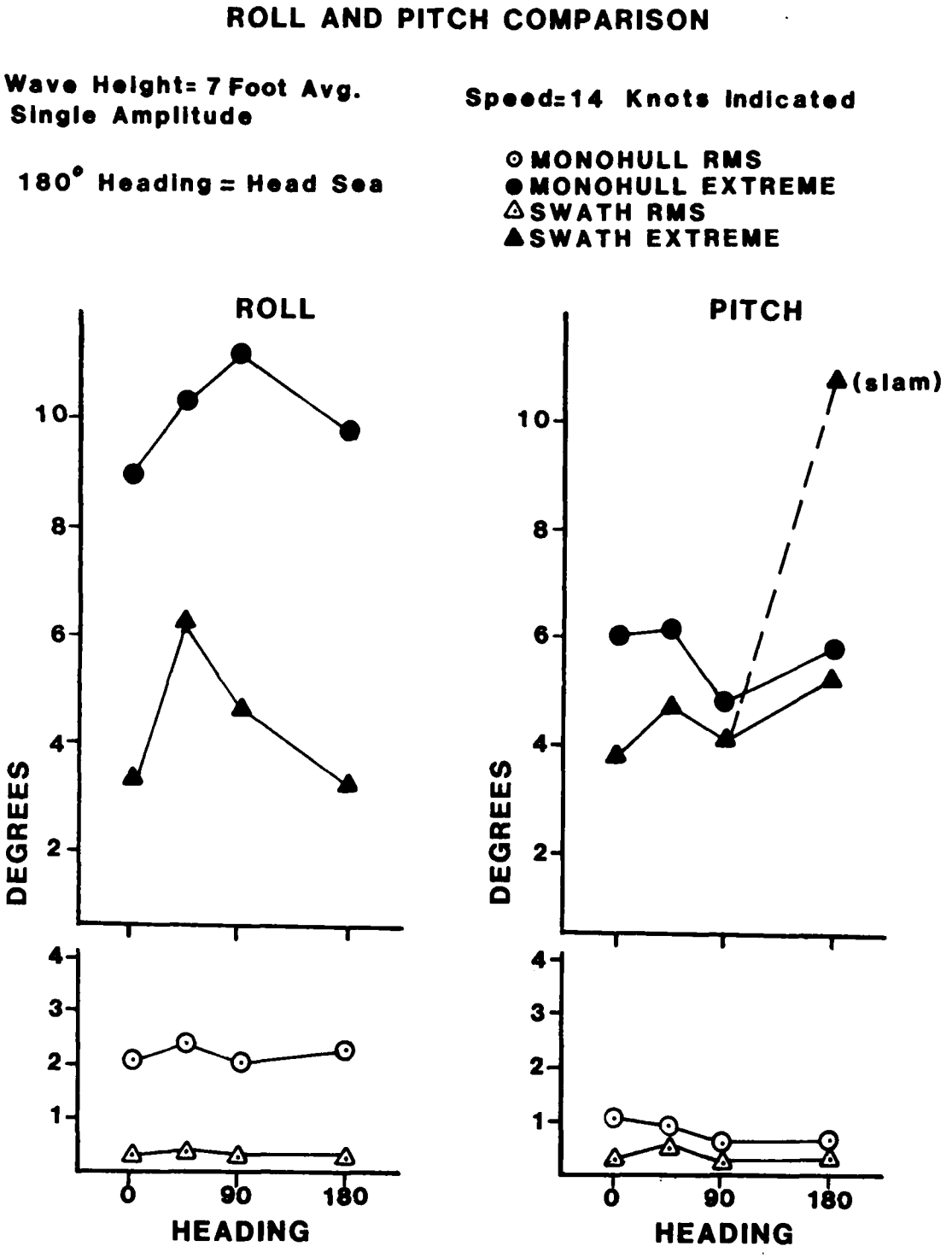

Figure 6. Roll and pitch comparison data.

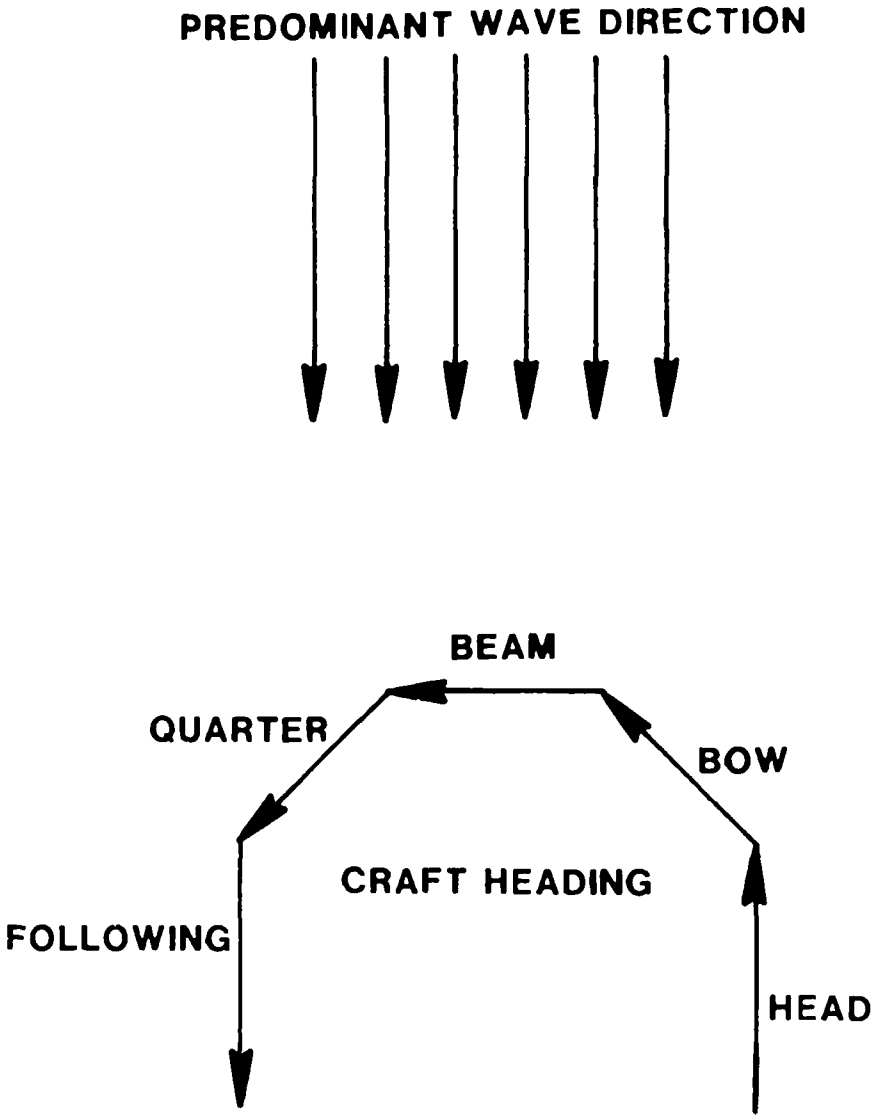

Figure 7. Craft headings.

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